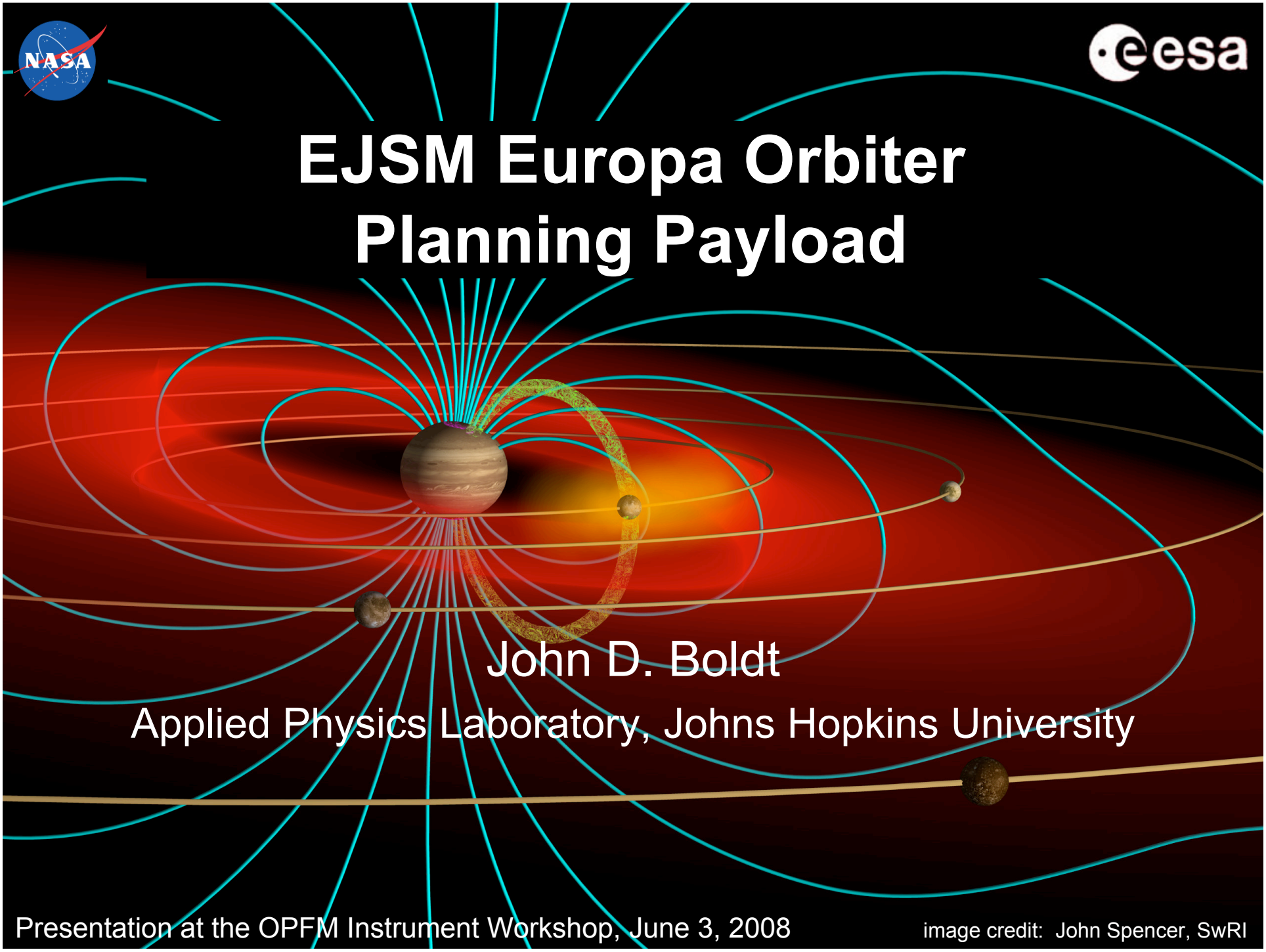


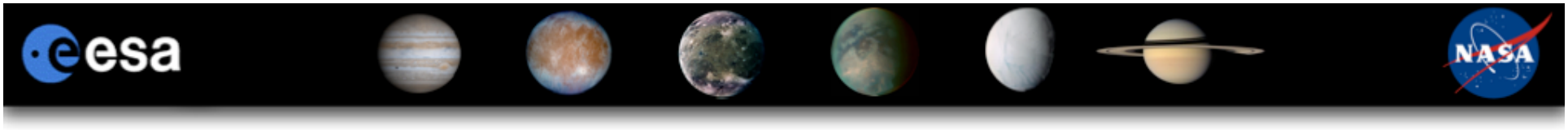
EJSM Europa Orbiter Planning Payload

John D. Boldt

Applied Physics Laboratory, Johns Hopkins University

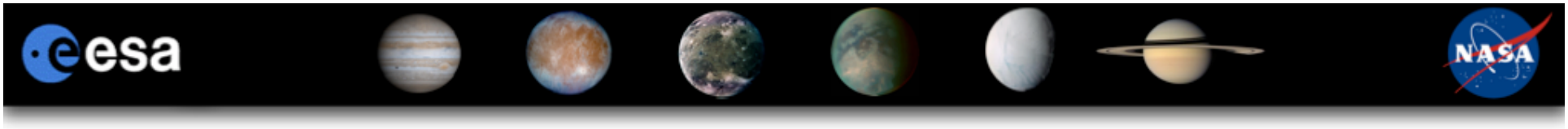
Presentation at the OPFM Instrument Workshop, June 3, 2008

image credit: John Spencer, SwRI



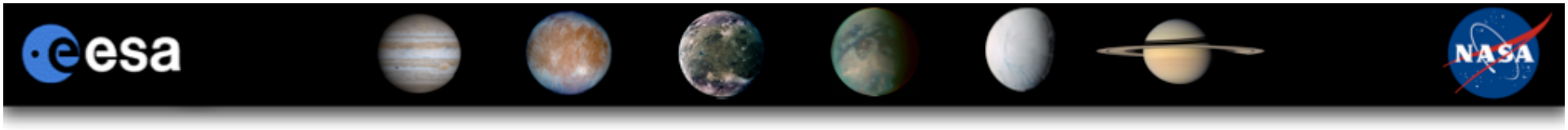
Planning Payload Philosophy

- The planning payload is selected to demonstrate that the mission is scientifically and technically feasible.
  - Science requirements and measurements can be achieved
  - Payload resources can be accommodated by the spacecraft
  - Payload development risks are manageable
  - Payload costs are consistent with the $2.1B mission cap
- The planning payload meets the measurement requirements and the resource constraints within the current cost cap.
  - Mass is currently not a driving concern
  - Power is currently not a driving concern (assuming 5 MMRTGs)
  - Cost is the primary concern and limiting factor for payload selection
- The planning payload is one means of meeting the science requirements defined by the Science Definition Team.
  - Alternative instruments and measurement techniques may be used to met the same requirements



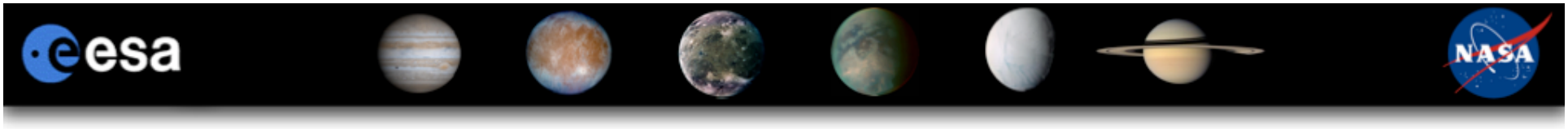
Planning Payload Implementation

- Instruments are assumed to be new designs for Europa in order to meet the radiation challenges for electronics and materials.
  - Radiation hardened application specific integrated circuits (ASICs) will replace field programmable gate arrays (FPGAs)
  - Radiation hardened mixed-signal ASICs will be a key instrument technology
  - The number of ASICs in each instrument is a parameter used in estimating payload cost
- Detectors are assumed to be new designs when estimating payload cost.
  - Radiation effects on existing detectors are under evaluation as an “existence proof” of technical feasibility



Planning Payload Implementation

- Instrument electronics are located remotely in a shared electronics enclosure(s) for increased radiation shielding.
  - Minimal electronics are assumed in the instrument optical assembly, sensor head, etc.
  - A Common 6U compact PCI (cPCI) form-factor is assumed
  - This approach has been assumed when estimating payload mass
- A standardized interface is assumed for all instruments to minimize risk and development cost.
  - Availability of commercial intellectual property (IP) will simplify development of radiation hardened ASICs
  - Instrument bandwidth points to SpaceWire as the standard interface
- Data compression is performed within the instrument.
  - Limited solid-state recorder size points to compression prior to recording



Planning Payload

• Camera Package	7.5 kg	11.7 watts
– Wide angle camera + medium angle camera		
• Spectrographic Imager	11.0 kg	15.0 watts
– Near-IR imaging spectrograph		
• Laser Altimeter	7.1 kg	15.1 watts
– Time-of-flight ranging		
• Magnetometer and Plasma Instrument	11.7 kg	14.0 watts
– Dual magnetometers		
– Low energy plasma sensor		
• Ice Penetrating Radar	36.0 kg	45.0 watts
– Dual frequency		

NOTE: all mass and power figures are current best estimate (CBE)

- Additional instruments to augment the core payload have been identified and prioritized. A listing is included at the end of this presentation

Camera Package

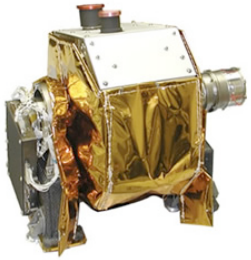
- **Primary science investigations**
  - Global stereo topography and surface color characterization
  - Correlation of surface features to geological processes
  - Characterize radiation effects on the surface
  - Local surface characterization at higher resolution

- **Measurement requirements – Wide Angle Camera**
  - Spectral Range: visible
  - Spectral Bands: 3 color plus panchromatic
  - Spatial Resolution: 100 m (IFOV = 1 mrad)
  - Image Width: 1024 pixels (58 degrees)
  - Signal to Noise: ≥ 100

- **Measurement requirements – Medium Angle Camera**
  - Spectral Range: visible
  - Spatial Resolution: 10 m (IFOV = 0.1 mrad)
  - Image Width: 2048 pixels (11 degrees)
  - Signal to Noise: ≥ 100

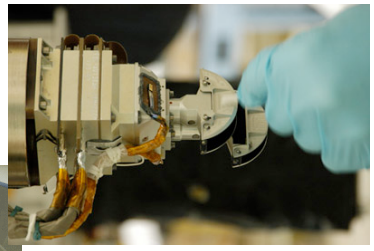
- **Configuration for Planning Payload**
  - Two telescopes, two detectors (CCD, pCCD or CMOS)
  - Pushbroom operation; fixed color filters for WAC
  - Passive cooling
  - Fixed nadir pointing
  - Electronics (6U cPCI): 1 WAC power/interface; 1 MAC power/interface

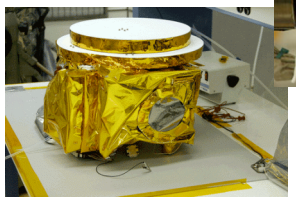
- **Similar heritage instruments**



MESSENGER MDIS

MRO MARCI





New Horizons Ralph/MVIC

- **Resource requirements**
  - Mass: 7.5 kg (CBE)
  - Power: 11.7 watts (CBE)

- **Operating Modes**
  - WAC global color mapping
    - 3 colors plus panchromatic, 12 bits
    - Cross-track overlap for stereo
    - Nominal 213 Kbps
  - MAC Targeted observations
    - Panchromatic, 12 bits/pixel
    - Nominal 1.07 Mbps (target bursts)

Spectrographic Imager

- **Primary science investigations**
  - Characterization of surface composition
  - Relate compositions to geological processes
  - Characterize radiation effects on the surface
  - Characterize exogenic materials

- **Measurement requirements**

– Spectral Range	~1.2 to ~4.8 μm	
– Spectral Resolution	10 nm	
– Spatial Resolution	100 m (IFOV = 1 mrad)	
– Image Width	~350 pixels (20 degrees)	
– Signal to Noise	≥ 100	

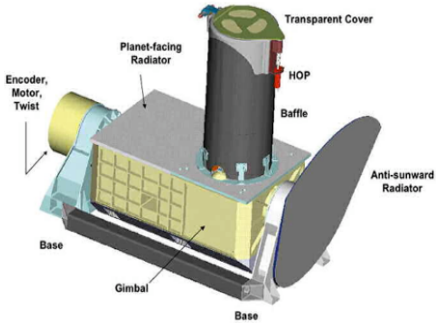
- **Configuration for Planning Payload**

– Single grating spectrometer	
– Single HgCdTe detector	
– Passive cooling	
– Fixed nadir pointing	
– Pixel processing options	spectral binning / editing
	spatial binning / editing
– Electronics (6U cPCI)	1 power supply
	1 pixel processor/interface

- **Resource requirements**

– Mass	11 kg	(CBE)
– Power	15 watts	(CBE)

- **Similar heritage instruments**



MRO CRISM

Moon Mineralogy Mapper

- **Operating Modes**
  - Global mapping
    - Spectral and special binning options
    - Spectral and spatial editing options
    - Nominal 100 Kbps
  - Targeted observations
    - 350 cross-track pixels, 408 channels
    - 12 bits per pixel, 13 frames/second
    - Nominal 9 Mbps (target bursts)

Laser Altimeter

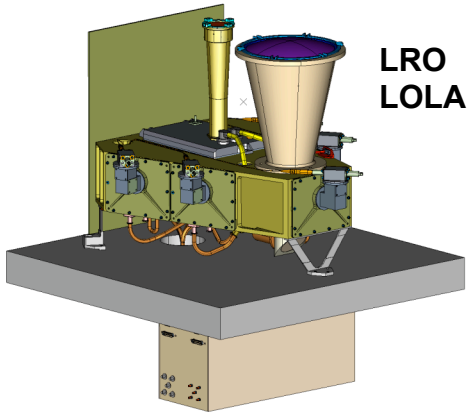
- **Primary science investigations**
  - Amplitude and phase of gravitational tides
  - Surface motion over the tidal cycle
  - Determine Europa's dynamical rotation state
  - Formation characterization of 3-D landforms

- **Measurement requirements**
  - Vertical Accuracy — < 1 meter
  - Horizontal Spacing — 50 meters
  - Spot Size — 50 meters (50 mrad)
  - Pulse Rate — 26 Hz

- **Configuration for Planning Payload**
  - 1.064 µm Nd-YAG laser with single spot
  - Reflective receiver telescope
  - APD detector
  - Fixed nadir pointing
  - Radiation hardened time-of-flight ASICs
  - Electronics (6U cPCI) — 1 laser power supply; 1 time-of-flight/interface

- **Resource requirements**
  - Mass — 7.1 kg (CBE)
  - Power — 15.1 watts (CBE)

- **Similar heritage instruments**



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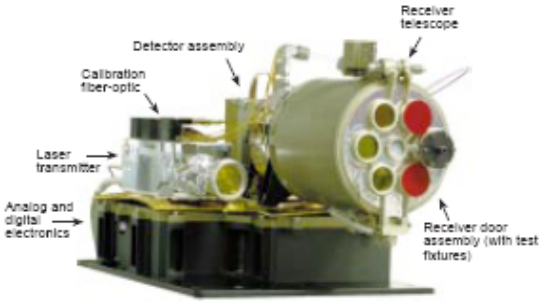


NEAR NLR

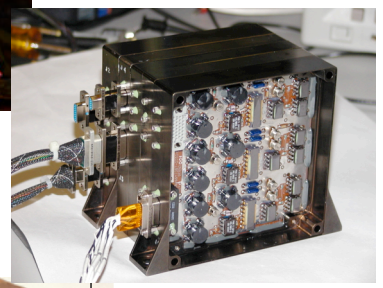
- **Operating Modes**
  - Continuous operation
    - 26 Hz pulse repetition rate
    - ~ 2.5 kbps

Magnetometer and Plasma Instrument

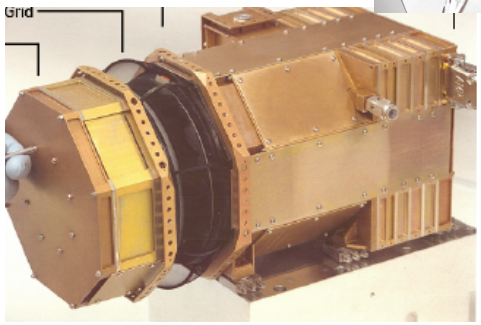
- **Primary science investigations**
  - Determine the induction response from the ocean
  - Investigate the core, mantle, and rock-ocean interface
  - Characterize the global radiation environment
  - Flux and composition of plasma ions impacting Europa
- **Measurement requirements - Mag**
  - Dynamic Range 3000 nT
  - Sensitivity 0.1 nT
  - Sampling Resolution 0.01 nT
  - Max Sample Rate 32 vectors/second
- **Measurement requirements – Plasma**
  - Energy Range 10 eV to 10 KeV
  - Angular resolution 15 deg
  - ΔE / E 0.15
- **Configuration for Planning Payload**
  - Dual 3-axis fluxgate Magnetometer probes
  - 10 meter spacecraft supplied boom
  - Single body-mounted top-hat plasma analyzer
  - Radiation hardened time-of-flight and energy ASICs
  - Electronics (6U cPCI) 1 Mag
    2 Plasma
- **Resource requirements**
  - Mass 11.7 kg (CBE)
  - Power 14.0 watts (CBE)

- **Similar heritage instruments**

MESSENGER MAG Probe



MESSENGER MAG Electronics



Deep Space 1 PEPE

- **Operating Modes**
  - Continuous operation
    - 32 Hz Mag sampling rate on orbit
    - 1 Hz Mag sampling rate during tour
    - 8 kbps

Ice Penetrating Radar

- **Primary science investigations**
  - Search for an ice-ocean interface
  - Characterize distribution of any shallow subsurface water
  - Correlation of surface features to geological processes
  - Characterize regional and global heat flow variations

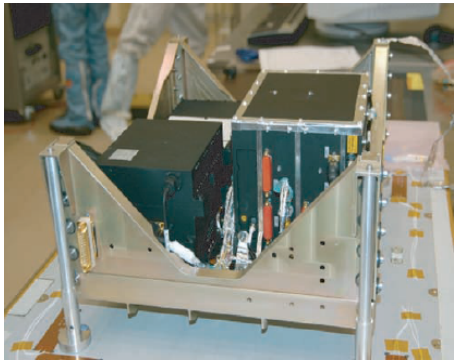
- **Measurement requirements**
  - 10 m vertical resolution for depths from 100 m to 3 km
  - 100 m vertical resolution for depths from 1 km to 30 km
  - 50 km profile spacing over 80% of the surface

- **Configuration for Planning Payload**
  - Dual-frequency sounder
    - 50 MHz with 10 MHz bandwidth
    - 5 MHz with 1 MHz bandwidth
  - Deployed dipole antenna
  - Range compression, pre-summing, Doppler filtering, data averaging, and resampling within the instrument
  - Electronics (6U cPCI) 6-8 boards

- **Resource requirements**
  - Mass 36 kg (CBE)
  - Power 45 watts (CBE)

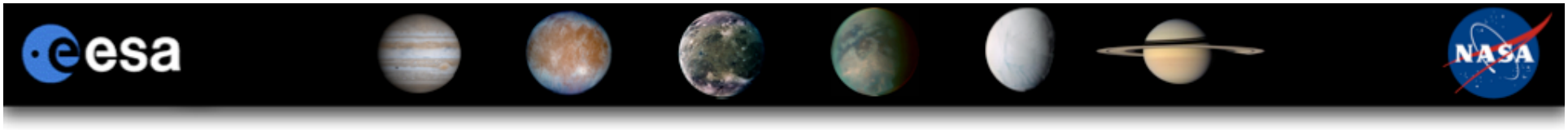
- **Similar heritage instruments**

MARSIS antenna prior to deployment



SHARAD Electronics

- **Operating Modes**
  - Shallow high resolution (50 MHz)
    - High spatial resolution (footprint and depth) above 3 km depth
    - ~300 Kbps
  - Deep low frequency (5 MHz)
    - Lower spatial resolution for probing an ice/ocean boundary to 30 km depth
    - ~300 Kbps
  - Raw data mode
    - Output unprocessed data
    - ~30 Mbps



Prioritized Additions to the Planning Payload

- **Narrow Angle Camera**
  - IFOV = 0.01 mrad
- **Augmented Spectrographic Imager**
  - Spectral Range 400 nm to 5 μm
  - Spatial Resolution 25 meters
  - Dual grating spectrometer, dual detector
  - Articulation for target motion compensation
- **UV Spectrograph** (minimum configuration)
  - Spectral Range 110 to 200 nm
  - Spectral Resolution 0.5 nm
  - Spatial Resolution 100 meters
  - Image Width 64 pixels
- **Thermal Imager**
  - Spectral Range 2-3 filters between 8 and 25 microns
  - Spatial Resolution 250 – 500 meters
  - 320x240 pixel microbolometer array with TDI
- **Energetic Particle Detector**
- **Ion and Neutral Mass Spectrometer**
- **Ultra-Stable Oscillator**
- **Dust Instrument**